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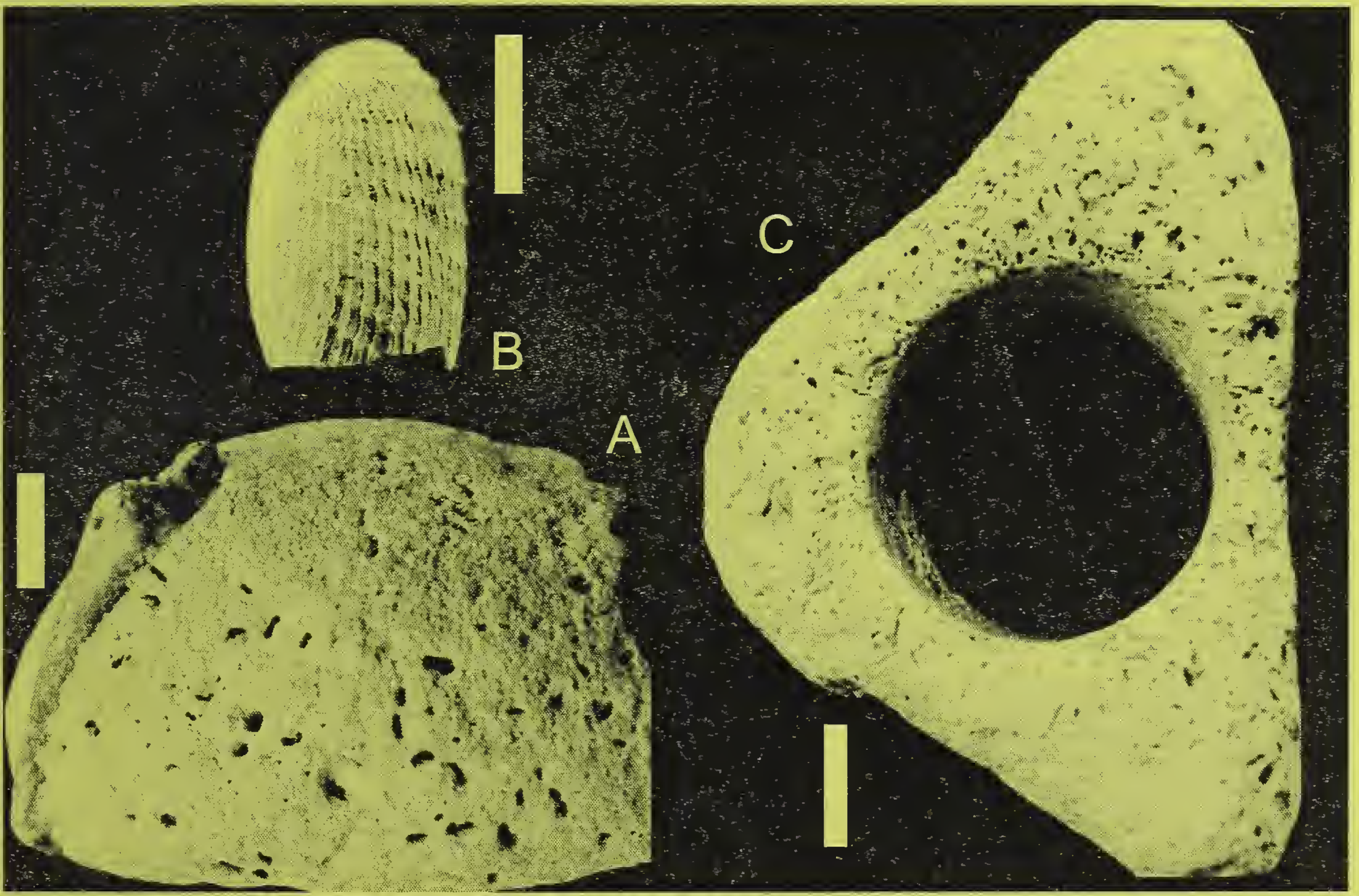
BULLETIN OF THE GEOLOGICAL SOCIETY OF NORFOLK

(FOR ARTICLES ON THE GEOLOGY OF EAST ANGLIA)

NO. 60 2010



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EDITORIAL

This issue of the Bulletin has a distinct palaeontological theme. The paper by Larkin and Norton principally describes the P. E. P. Norton Collection of East Anglian early Pleistocene Mollusca, part of the geology collections of Norfolk Museums and Archaeology Service. The paper serves as a timely reminder that there is currently a dearth of fieldwork, research and skills in this area of Pliocene/Pleistocene mollusc identification and the authors strongly encourage amateurs and professionals alike to get involved in the subject. Similarly, the paper by Donovan demonstrates the palaeontological details to be found in Norfolk beach pebbles.

A brief note on the health of the Bulletin is also apposite at the close of the first decade of the 21st Century. Since publication of Bulletin 51 in 2001 we have published 28 papers, about 3 per issue on average. The average paper length has been around 23 pages and on average each Bulletin has been around 70 pages in length. This suggests the Bulletin has remained in good health and at similar levels of productivity to the 1990s. I do hope we can sustain this level of interest in East Anglian geology for many years to come.

INSTRUCTIONS TO AUTHORS

Contributors should normally submit manuscripts either as word-processor electronic files (MS Word is preferred) or hard copy. When papers are accepted for publication we will request an updated electronic version.

It is important that the style of the paper, in terms of overall format, capitalisation, punctuation etc. conforms as strictly as possible to that used in Vol. 53 of the Bulletin. Titles and first order headings should be capitalised, centred and in bold print. Second order headings should be centred, bold and lower case. Text should be 1½ line spaced. All measurements should be given in metric units.

References should be arranged alphabetically in the following style.

BALSON, P.S. & CAMERON, T.T.J. 1985. Quaternary mapping offshore East Anglia. *Modern Geology*, **9**, 221-239.

STEERS, J.A. 1960. Physiography and evolution: the physiography and evolution of Scolt Head Island. In: Steers, J.D. (ed.) *Scolt Head Island* (2nd ed.), 12-66, Heffer, Cambridge.

BLACK, R.M. 1988. *The Elements of Palaeontology*. 2nd Ed., Cambridge University Press, Cambridge. 404pp.

We hope to make pdf versions of all papers from now on to serve as offprints for authors and for possible future WWW availability. For this reason we prefer illustrations drawn with a computer graphics package, ideally saved in jpeg format. Thick lines, close stipple or patches of solid black or grey should be used with care as they can spread in printing hard copy. The editor may have diagrams re-drawn professionally and usually the GSN will cover the cost of this. For efficient use of space full use should be made of the width of print on an A4 page when designing diagrams. Half tone photographic plates (if possible reproduced as jpeg files) are acceptable provided the originals exhibit good contrast.

The editors welcome original research papers, notes, comments, discussion, and review articles relevant to the geology of **East Anglia** as a whole, and do not restrict consideration to articles covering Norfolk alone. All papers are independently refereed by at least one reviewer.

THE PLIOCENE AND PLEISTOCENE MOLLUSC ARCHIVE AT NORWICH CASTLE MUSEUM

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ABSTRACT

This paper is one in a series of recent projects researching and documenting the geology collections of Norfolk Museums and Archaeology Service. It describes three years of work databasing the P. E. P. Norton Collection, formed between 1961 and 1978, whilst researching the East Anglian early Pleistocene Mollusca and those of associated sites, with comparative and reference specimens from the Pliocene, Pleistocene and Holocene of NW Europe and Iceland. Several of the collection sites no longer exist. The resulting database, of 1925 records and 4500 images, the collection itself and associated documents, together with unresearched material donated to the British Geological Survey, form an accessible resource for future documentation of other specimens or collections. The database records 'monstrosities', 'attacked' and parasitized shells, new findings on Macoma balthica*, and taxa which require further examination. The database forms a 'Digital Monograph' including illustrations of not only the best but also the least identifiable shells. A preliminary survey of other mollusc collections in Norwich Castle Museum, mainly from the 19th Century, is also summarized together with a brief guide to other institutions possessing cognate material. The limitations of the collection are discussed. Suggestions for new approaches in future work are included, with particular emphasis on the need to build-up new collections with modern tools and methods and at finer resolution of stratigraphic detail and site description. New directions may include biomass estimation and other palaeoecological studies. An Appendix lists many of the earlier mollusc collectors and the location of their stored material.*

Bull. geol. Soc. Norfolk (for 2010) **60**, 3–35.

INTRODUCTION

The geology collection at Norwich Castle Museum & Art Gallery (NCM), formerly the Norfolk & Norwich Museum, consists largely of several discrete sub-collections of fossils, rocks and minerals donated by various individuals during the 200 years since the formation of the Norwich Museum in the early nineteenth century. The geology collection contains approximately 80,000 individual specimens, of which approximately 21,000 have now been fully documented digitally and the records made available for research over the internet (for information about the NCM database see Hoare & Larkin, 2008). Several of the older collections were assembled by amateur geologists who were at the forefront of the development of geology in Norfolk and farther afield including A. Bell, F.A. Buxton, E. Charlesworth, W.M. Crowfoot, E.T. Dowson, J. Gunn, F.W. Harmer, H. Norton, J. Reeve, C.B. Rose, S.V. Wood Snr & Jnr, and S. Woodward (see Appendix: Collectors and donors: some biographical notes). Many of their specimens are amongst the 360 Type, Figured or Noted specimens known to be in the collection.

The more important parts of the NCM geology collection have now been fully documented digitally using MODES (Museum Object Data Entry System) software to create a database that is not only fully searchable but able to be examined over the internet (including many photos). These fully documented sub-collections include: all the Type and Figured vertebrate material; the mineral collection; glacial erratics (see Hoare & Larkin, 2008); the Paul Whittlesea collection of Chalk fossils donated in 1985; trawled and dredged fossil mammal material from the North Sea; fossils from the Cromer Forest Bed Formation; and vertebrate fossils from the Crag (the last two collections were documented with Designation Challenge Funding). Also, approximately 5,500 Cretaceous echinoid fossils from East Anglia and further afield (many from sites no longer available) collected by Norman Peake have been documented (work undertaken by Paul Whittlesea, 2006–2007).

Most recently, work has begun on the vast and important collection of Mollusca from the Pliocene and Pleistocene sediments of East Anglia and related deposits abroad. As part of this process, the Peter Norton collection of Pliocene and Pleistocene Mollusca has recently been fully documented as an important research collection in its own right and in order to produce reference material to help identify the many thousands of Pleistocene mollusc specimens in the NCM archive awaiting documentation.

THE P.E.P. NORTON COLLECTION

Chronology

Peter Norton (PEPN) worked on Pliocene and pre-glacial Pleistocene molluscs in East Anglia, the Netherlands and Iceland. Commencing in Cambridge in 1961–1964 as a PhD student in the Sub-department of Quaternary Research, and continuing in the University of Glasgow Zoology Department from 1974–1978, his collecting and research was undertaken during the years 1961–1978, with 18 publications during the years 1966 to 1991 (see references). On retirement from 23 years stipendiary clergy service in 2004, he decided to revisit some items of malacological interest, such as the distorted mollusc forms found in the Crag deposits. This was made possible by appointment as a (volunteer) Research Associate of the Norwich Castle Museum Natural History Department, working at Gressenhall in central Norfolk where the geology collections were stored after the redevelopment of NCM in 1999-2000.

In the process of packing and moving the material, many of the collections made by named persons (see above) ceased to be stored as discrete units. The first task undertaken was to assess the specimens crated in several different areas of the stores. This was recorded as an Excel Spreadsheet allowing for detailed searching and filtering of the data. It specified (where possible) distinct collections to which the shells had belonged, names of persons who had collected and identified the specimens, the find localities, any special characteristics, a subjective assessment of the scientific value of the specimens, and at what priority they might be researched. Though not complete, this file runs to some 900 rows and 12 columns. More details are given below.

These collections spanned a century and more and there were many problems of nomenclature and conservation. To make available a documented reference collection to aid identification and clarify nomenclature was the next step required. PEPN's own reference collection was the obvious choice as it already had a written index with references to related field notebooks, ecological and taxonomic works, photographs and drawings and contributions by research colleagues. Putting this collection onto the MODES database took from autumn 2005 to late summer 2008. All the material is now physically available for study and research at Gressenhall (see below). A collection of associated reference works, reprints from periodicals etc. was also left at Gressenhall.

The PEPN collection and its MODES database is a kind of 'digital monograph'. It was not originally designed to be a reference collection. Rather, it contains specimens set aside in the course of research, so that determinations could be checked later. These vary from perfect to those in very bad condition, as opposed to published illustrations which generally show complete and well-preserved forms. The descriptive and diagnostic notes in the MODES records indicate the degree of certainty PEPN placed on his determinations, with some reasoned notes on what is 'not determinable'.

A collection of PEPN's geological field samples, extending to some 33 wooden boxes (each 440 x 330 x 210 mms) including a card index with references to collecting details and research done, has been deposited with the British Geological Survey at Keyworth (20/08/2008, Bulk Reference Number DRF577, awaiting curation). The University of Glasgow Archive Service contains a collection of PEPN manuscript material (1977–1978, reference number GB 2048 DC 375).

Scope of the collection: resumé of collection sites (Fig. 1)

a) Iceland, Tjörnes. Pliocene to Early Pleistocene: collecting trips with Gerard Spaink [Netherlands Geological Survey] and Yuri Gladenkow [USSR Academy of Sciences Geological Institute, Moscow], 1969, 1972. Holocene: Tjörnes and Reykjavik beaches, 1969.

b) Denmark, Isefjord. July 1972.

c) Holland, various. Early Pleistocene to recent material (donated by Gerard Spaink, various dates).

d) Belgium, Antwerp Docks. Pliocene (donated by Gerard Spaink).

e) Scotland. 'Late Glacial': the Clyde Clay (with Jim Rose). Holocene: Clyde Estuary, Millport, Dunbar..

f) East Anglia:

- Red Crag (Walton on Naze, Bawdsey)
- Norwich Crag (Aldeburgh Brickyard, Chillesford Churchyard Pit 1968, 1970, Thorpe Aldringham Shellpit Cottages, Sizewell Nuclear Power stations A, 1961 and B, 1970, Easton Bavents 1966, Aldeby 1966, Wangford Hill Farm 1968, Caistor St Edmunds 1975, Bramerton Common and Blake's Pit 1975, Wroxham Old Hall 1964 and Dobbs Lane 1975, the University of East Anglia Boreholes project 1968. Ludham Royal Society Borehole 1961.
- Weybourne Crag (West Runton 1961, 1967, 1972, Sidestrand 1961)

g) Plymouth. Holocene: Eddystone Shell Gravel (donated by Norman Holme, Marine Biological Association).

h) Isles of Scilly. Holocene: Tresco, 1962.

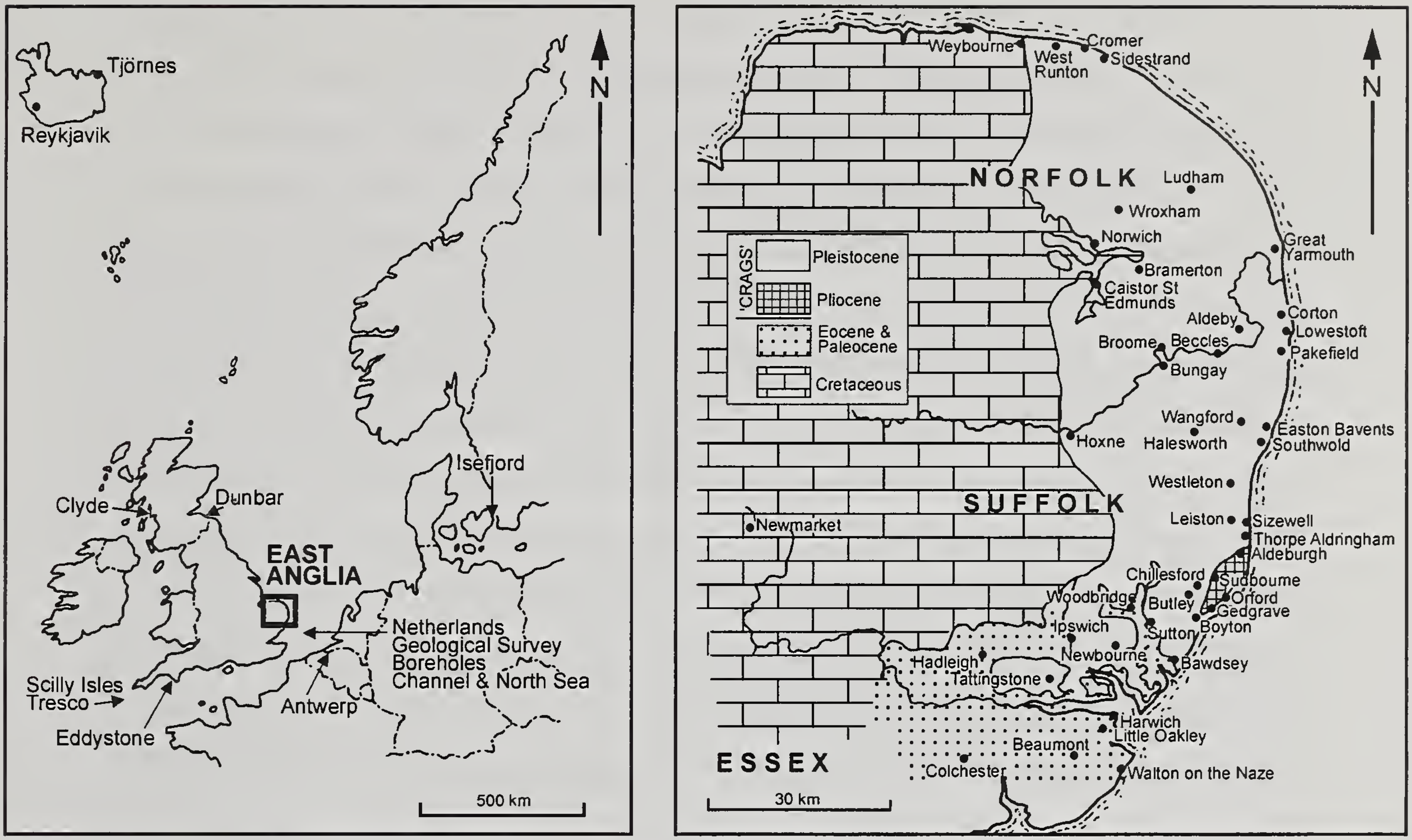

Fig. 1. Map of northwest Europe (left panel) with enlargement of East Anglia (right panel) showing locations of all the major sites within the PEPN collection database.

Highlights and limitations of the collection

An archive of material from sites no longer available

The collection and the bulk samples deposited with the British Geological Survey contain material from sites which are no longer available to collectors. These are:

i. Site excavations now beneath Sizewell Nuclear Power stations A and B.

ii. West Runton and other North Norfolk coast sites, now eroded.

iii. Easton Bavents cliffs, now eroded.

iv. Antwerp Docks, excavations now flooded.

v. Clyde clays at Renfrew By-pass, now landscaped.

vi. Caistor St Edmund: the Pleistocene shelly material was largely bulldozed off in 2008. The bulk samples PEPN collected there in 1975 have not been researched.

Small is beautiful and thanks to digital imaging, visible too

Searchable Notes in the database point to some particularly fine specimens and beautiful small shells, including among many others the Gastropods *Cingula semicostata, Chrysallida indistincta, Margarites cinereus, Natica clausa* and *N. hemiclausa, Odostomia eulimoides, Retusa mammillata, Scala clathratulum (*and *S.c. minutum)* and Bivalves *Chlamys opercularis, Crenella decussata, Neotrigonia margaritacea* and *Tellina tenuis.* Some juvenile Pyramidellid material demonstrates the sequence of growth of the heterostrophic apices, which begin sinistral and switch to dextral, becoming either coaxially involute or perpendicularly protruding in the apex of the growing shell. Maximum dimensions of the above specimens range from 0.5 mm to 20 mm. Full measurements are given in the relevant MODES records.

PEPN discovered one species and genus new to science: a tiny bivalve *Altenaeum nortoni* Spaink 1972. The Norton collection contains 5 specimens, two are Paratypes. The Holotype is in the Naturalis Museum, Leiden, Holland, *ex* Netherlands Geological Survey.

Important records of monstrosities, 'challenged' Mollusca etc

In the course of documenting the PEPN and other collections at Gressenhall, notes were made of specimens showing distortion or other monstrosities, parasitism, encrustation by barnacles, 'bryozoa' and suchlike, attacks by crabs, drilling by *Natica,* manganese and ferruginous coatings, possibly derived specimens and 'chemical varnish', etc, which may be of assistance to cognate researchers. It is clear that predators have individual, prey-species dependant, strategies. Crabs chip away the aperture of gastropods, *Natica* attacks particular areas of *Nassarius* or other gastropods, using the prey's external ornamentation to find a suitable penetration point, often the ventral side of the body whorl. Bivalves are often drilled at the adductor muscle attachment areas.

Monstrosities are sometimes attributable to epifauna such as barnacle Cyprid larvae settling on growing areas of gastropod shells. In the past such specimens have occasionally been named as new varieties (Funnell *et al*, 1979; Reid, 1996). Other gastropod monstrosities have been shown to be caused by Trematode parasites, which settle in the gonads and render the host sterile (Thieltges & Buschbaum, 2007; Buschbaum *et al,* 2008).

New findings on the **Macoma balthica** *question*

- The bivalve genus *Macoma* includes species which are considered to be 'guide fossils' *viz:* stratigraphic marker fossils, known to have lived in a particular geological age that can be used to date the rock layer in which it is found.
- Particular attention has been given to the diagnostic characteristics of these *Macoma* species, extending the work of Spaink & Norton (1966).
- Recent publications suggest there was a Pliocene *M. balthica* genetic complex in the north Pacific and that the species reached the North Sea in migratory waves when the Bering Straits were open (*e.g.* Nikula *et al* 2007).
- *Macoma balthica* is regarded as a stratigraphic marker. It first occurs in East Anglia in the Weybourne Crag. Various records of *M. balthica* from the 'Bure Valley Beds' and the Norwich Crag were reviewed by Norton (Funnell, Norton & West, 1979). The Bure Valley Beds were (often) held to be younger than the Norwich Crag but older than the Weybourne Crag. The Bure Valley Beds are included in the Wroxham Crag by Rose *et al* (2001). The museum specimens of *M. balthica* from the Bure Valley Beds and the Norwich Crag proved in fact to be *M. praetenuis* or *M. obliqua.*
- Later (1970s: the exact date is not clear), Philip Cambridge recovered 20 shells, which he identified as *Macoma balthica,* from the 'Bure Valley Beds' at Dobbs Lane, Wroxham. This material, now in the Sedgwick Museum, Cambridge, was also examined by PEPN. A separate small MODES database was formed for these specimens, a copy of which is held by the Sedgwick Museum. There proved to be 18 *M. obliqua* or *M.* cf. *obliqua* juveniles. Two specimens were apparently intermediates between *M. obliqua* and *M. balthica.* These were determined as "*Macoma cf. balthica* or *cf. obliqua*" and "*Macoma cf obliqua* or *cf balthica*", *i.e.* the former being closer to *balthica* and the latter closer to *obliqua.*

Palaeoecological research

Research by PEPN has taken two other directions:

Firstly, the evolution of ecological units greater than the population level. Work by J.W. Valentine (1968) followed publications on Marine Animal Communities (e.g. Jones, 1950). PEPN attempted to review bases for prediction of future changes in the North Sea benthos such as those caused by the global warming process (Norton, 1978), which could have implications for the fishing industry.

Secondly, estimates of biomass: G. H. Petersen (1977) surveyed the density, biomass and origins of the bivalves in the central North Sea. Attempted 'paleo–biomass' estimation by A. Hendy in the USA has led him (personal communications, 2007–2008) to attempt biomass estimates for the Plio–Pleistocene Mollusca of Tjörnes, Iceland, using data from PEPN (Norton, 1975). The PEPN collection (and the collections in the Natural History Museum, Reykjavik) contains examples of the molluscs whose paper records are the basis of Hendy's estimates.

Limitations of the collection and possible future work

The PEPN collection has several limitations, which might be addressed in future:

a) The specialist re-examination of several taxa would be beneficial, especially Naticidae, Pyramidellidae, Rissoidae, Astartidae and Myacea.

b) Imaging of the smaller specimens (maximum dimension 0.3 mm to 80.0 mm) was done through a Wild M5 stereoscopic microscope with trinocular, Leica adapter with Canon Supershot 80 digital camera and remote-capture Canon computer software. The x50 objectives of the M5, which was 40 years old, had deteriorated over time, and sharp pictures were difficult to obtain at this magnification. With a better microscope, the use of 'three dimensional simulation' software or by Scanning Electron Microscopy, improvements could be made. For specimens larger than 80 mm, a Leica M8 digital camera with reflex box and bellows and 90 mm objective was used.

c) PEPN's well-documented samples at the BGS: research could be undertaken on unexamined samples, for instance some of the University of East Anglia borehole series, Caistor St Edmund and Broome Common Borehole.

For specialist malacological advice concerning material of this age, good starting points are the British Museum (Natural History), Natures Museum in Leiden and the Teyler Museum in Haarlem, Netherlands.

Usefulness of the collection for future research in Crag geology

The collection was formed at a time when the Crag stratigraphy was being rewritten on the basis of a series of assemblage biozones based on pollen, foraminifera and molluscs. The molluscs were studied for palaeoecological purposes. Counts of individuals of the different species were taken and the species were divided into ecological groups, a method developed by Norton and used for work on the 'Norwich' and 'Weybourne' Crags and for the Pliocene–early Pleistocene deposits of the Tjörnes peninsula, northern Iceland. As a control procedure the Eddystone Shell Gravel (Holocene) was researched in the same way (unpublished MSS, BGS, ref. DRF 577, material deposited by PEPN). Similar approaches have been made in research on the Red Crag (Dixon, 2007). The mollusc analyses enable studies of facies change over time or area, but did not produce a new malacologically based stratigraphy for the Crag deposits. The reason for this may be the comparatively limited timescale represented in the Crag deposits and the limited zoogeographical resource from which the Mollusca were recruited, (Norton, 1975, 1977; *cf.* West, Norton & Funnell, 1980).

The Crag stratigraphy has again been revised in the course of work by the British Geological Survey (Rose *et al.,* 2001). These initial findings concerning the extent of the 'Wroxham Crag' can usefully be complemented by studies of the ecological facies indicated by the Mollusca which occur in the known exposures or which have been recovered in the many borehole records, researched or yet to be researched. (J. Rose, pers. comm. 2006).

Processes involved in documenting the molluscs to produce the MODES database

MODES is the most widely used cataloguing system in British museums (it is used by more than 330 museums and archives, of all types and sizes). The data structure is based on national standards, the retrieval of information is by index or free text searching and it has built-in links to images, texts and other multimedia resources with public access web server applications able to deliver records over the internet to clients using a standard web browser. Fields can be updated at a later date if required. For general information on MODES, visit http://www.modes.org.uk/

The MODES database software enables a very detailed log to be created for each specimen. Every specific sub-heading ('field') is listed in individual cases, but there is not always sufficient information available to permit an entry against each field. Since the terminology is specific to the MODES software, some explanation may be helpful. As an illustration, an actual record from the database is given in Appendix I. The text that appears in the record is in regular type and explanations are added in italic. Photographs of the specimens concerned (Appendix I, Fig. 2) appear within the record on the database.

AN OVERVIEW OF THE OTHER PLIOCENE AND PLEISTOCENE MOLLUSC COLLECTIONS IN THE NCM ARCHIVES

For biographical and other details of the collectors, and more exact details of specimens associated with them see the Appendix. PEPN's spreadsheet file – see above – can be consulted for much fuller details.

In general, the specimen labels record only the species name and the place where the specimens were found. In a few cases, the stratigraphical level from which the specimens were recovered has been recorded, and the date of collection and collector's name. Many specimens lack the find locality, merely stating, e.g., 'Red Crag.' Very few state the authorship of the species. This is normal for collections of this age, which are almost entirely 19th century. Very few specimens have full details of name, authorship, locality and stratigraphy.

The important collections (not researched in detail by PEPN) relating to Pliocene and Pleistocene molluscs are:

The NCM Type and Figured collection

This contains approximately 57 specimens of new molluscan species, subspecies or varieties, which have been published in monographs or other descriptive works. A register (and MODES records covering some but not all of this collection) are available, also a printed list (Leney, 1902).

The Crowfoot collection

Consisting of one cabinet of specimens at the Shirehall Study Centre in Norwich, and one at Gressenhall. The latter has 15 drawers of East Anglian early Pleistocene shells and 14 drawers of material from Mosbach, Hampshire Basin Tertiaries and Paris Basin Tertiaries.

The Searles Wood Collection in Superstore 1 at Gressenhall

This important collection has been kept together. It consists of 75 stacked plastic trays G1086 to G1156 corresponding roughly to the drawers in a previous wooden cabinet, containing mollusca from the following:

i. "Recent'
ii. Interglacial, Glacial and Holocene shells
iii. Pleistocene Freshwater Shells
iv. Corton Beds
v. Upper Freshwater Bed
vi. Icenian Crag
vii. Red Crag
viii. Coralline Crag
ix. British Lower Tertiaries, Hampshire Basin, Continental Tertiaries and 'American'.

Of these, numbers (v) to (viii) occupy 25 of the 70 trays in the collection. Many of the specimens are very dusty. The labels are often written in pencil, give few details, and will require conservation before attempting to read them.

Various other collections in Superstore 2 at Gressenhall

(each 'G' number denotes a whole crate or drawer)

- G107 – Red Crag, Waldringfield Heath
- G164 and G465 – Geology Display shells, Crags, various sites
- G762 and 763 – Red Crag
- G764 – Norwich Crag: Aldeby, Easton Bavents, Bramerton, specimens from collectors Crowfoot & Dowson, Reeve
- G765 – Aldeby (Crowfoot & Dowson) Postwick and Thorpe (Norwich, collected by Wigham), Easton Bavents, Bungay
- G766, 767, 768 – Red Crag (Sutton etc)
- G769 – Icenian, Bramerton (Reeve)
- G770 Red Crag, Felixstowe (collected Rev. F A. Buxton, S.V. Wood)
- G771 Red Crag, Oakley (Fitch Collection)
- G772 Red Crag
- G773 Red Crag, Walton on Naze
- G775 Red Crag, Revd F. A. Buxton Collection

- G776 Red Crag
- G777 – localities not given – Red Crag? – some are Buxton Collection
- G778 Red Crag Waldringfield, Bawdsey, Butley, Felixstowe, Chillesford – some '1869' – some are Hawes Collection, some 'collected A. Bell, H Norton Collection'
- G779 – Felixstowe – some '1869' – some 'Butley, 1873, A. Bell' – some Walton on Naze – Waldringfield, Sutton, H Norton Collection – Aldeburgh
- G780 – Red Crag (A. Bell, 1873) – Waldringfield, Aldeburgh Red and Coralline Crag (sic) – Chillesford Red Crag – Sutton Red Crag – Butley, H. Norton Collection – Felixstowe Red Crag
- G781 – Red Crag, Oakley
- G782 Red Crag – Sutton etc
- G783 – Red Crag
- G785 – Waldringfield, Red Crag
- G787 – Red Crag, Buxton Collection
- G789 – no localities
- G1009 – Crowfoot Collection
- G1012 – H. Norton Cabinet – non British Pleistocene – Selsey
- G 1014 and G1017 – Thorpe (Norwich?)
- G277 – Freshwater Bed , Fitch Collection – Nar Brickearth (Rose Collection) – North Norfolk Coast Cromer Forest Bed material – Weybourne Crag. Weybourne, West Runton (Reeve Collection) (in 'Bisley' cabinet).
- G279 – many with no locality – some Fitch Collection – Bramerton – Coltishall (Reeve Collection, Rogers) – Wangford (in 'Bisley' cabinet).

FURTHER SOURCES OF INFORMATION REGARDING EAST ANGLIAN PLIOCENE AND PLEISTOCENE MOLLUSCS

The Norwich Castle Museum collections (other than the PEPN collection) summarized above apparently contain no specimens from the deposits at depth. None labeled as coming from boreholes or wells was encountered in PEPN's preliminary assessment of the collections in the stores at Gressenhall. The 19th and early 20th Century collectors, as well as the officers of the Geological Survey, equipped as they were with hammers, spades and pickaxes, worked on surface exposures in cliffs and pits.

PEPN obtained many samples from boreholes (see above, '*Scope of the*

Collection: resumé of collection sites). In addition to specimens in the PEPN collection at Gressenhall, the material deposited by PEPN at the British Geological Survey, Keyworth (reference number DRF577) includes intact and unresearched borehole samples from the UEA borehole series made in 1969 (Beccles, Yarmouth, Stradbroke, Hoxne, Syleham, Yare Crossing, Oulton Broad, and Rockland – details are available from the UEA School of Environmental Studies), also from Broome Common (1963), Outney Common, Bungay (1963) and Trimingham (1980). Boreholes have since been drilled by the BGS and associated institutions, e.g. Dept of Geography, Royal Holloway College, London (J. Rose, pers. comm. 2006).

In addition to the above there are museum collections of Crag Mollusca elsewhere, in particular:

- Ipswich Museum. Documentation of these is ongoing; online access is currently not available.
- The Natural History Museum, London – especially material from Harmer.
- The Sedgwick Museum, Cambridge – especially the Harmer and Philip Cambridge collections. Online searching is not yet available. The database of specimens is under development at present.
- The Yorkshire Museum has Crag material. This is reported to be well documented. (W. Watts, Scarborough Museum, pers. comm. 2007)

CONCLUSIONS

The PEPN collection is a valuable online and physically available resource for research into Pleistocene molluscs, Pleistocene stratigraphy and climate change. It is particularly useful as a reference collection for identifying Pleistocene molluscs, both those newly collected and for the further documentation work required on the NCM collections. It is still an active research collection, and publications will soon be forthcoming concerning the palaeoecological significance of many of the specimens. Its importance for future work on the early Pleistocene is perhaps as a pioneer. Time will tell whether the labour of conserving, curating and documenting many of the 19th century collections from NCM is worthwhile, considering the prevalent lack of stratigraphic information recorded about the shells. Where the specimens are from sites that are no longer available or are important for taxonomic reasons, then obviously they should be researched. In other cases they may be good for display purposes, but selectivity is necessary. There is a need to build up new collections with modern tools and methods and a finer resolution of stratigraphic detail and site description. Teamwork will be needed, rather than the labours of individualists, which have so dominated the scene in the past.

What may follow from the research summarized in this paper? Are there economic insights to be gained? Possibly, future studies of the benthic marine invertebrate assemblages in the Early Pleistocene deposits of East Anglia and other places in north–west Europe may be directed towards providing estimates of palaeo–biomass and how it varied over time with temperature, water depth and other hydrological factors. This might be important for fisheries research, in predicting the effects of climatic change into the future. The North Sea benthos is a vital natural and economic resource, to be understood and conserved, feeding as it does the fish stocks which are a vital part of our food supply. Its history and future require deeper understanding. We suggest European cooperation, in all countries concerned for the North Sea and its creatures in space, time and economics.

ACCESSING, AND ASSISTING WITH, THE NCM ARCHIVE

To search the collections of Norfolk Museums and Archaeology Service, including Norwich Castle Museum, go to this webpage:
http://www.culturalmodes.norfolk.gov.uk/projects/nmaspub5.asp

If you require assistance with searching NCM's collections, visit the following webpage:
http://www.museums.norfolk.gov.uk/default.asp?Document=300.01.099x1

Those who wish to examine specimens in the geology collection in the 'Superstore' at the Gressenhall Farm and Workhouse Museum of Norfolk Life, or would like to assist with documentation projects, please contact: the Curator of Geology, the Natural History Department, Norwich Castle Study Centre, Shirehall, Market Avenue, Norwich, Norfolk, NR1 3JQ.

Volunteers are needed to assist with documentation projects within the NCM collections, specifically the collections of Pliocene and Pleistocene molluscs – contact the Curator. If there are other collections in private hands and needing a home, the Norwich Castle Museum is now a sensible place for them to be curated and made available.

ACKNOWLEDGEMENTS

We are grateful to Dr. Tony Irwin, Martin Warren and Ann Ainsworth for advice and help within Norfolk Museums and Archaeology Service; Dr Liz Harper of the Sedgwick Museum, Cambridge for access to collections; Professor Richard West for loan of reference works; Dr Peter Long of Leicester University for discussions about diagnoses and diagnostic literature; and Dr Peter Hoare for comments on earlier drafts. Also Dr Julia Sigwart and Dr Matthew Parkes of the Natural History Museum of Ireland, and the Geological Survey of Ireland for library facilities. Posthumously, to Gerard Spaink of the Netherlands Geological Survey, field companion and donor of much reference material courtesy of the NGS. It has been our privilege to spend time and effort in this branch of science.

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[Manuscript received 3 August 2009; revision accepted 17 January 2010]

APPENDIX I

EXAMPLE OF A FULL MODES RECORD (NWHCM : 2006.172.1719)

Record number	NWHCM : 2006.172.1719 : G *A unique identifying number. The format is* *< NWHCM = museum identifier (Norwich Castle Museum)>:* *<2006 = year>* *<.172 = collection accession number in that year>* *<.1719 = part number (i.e. record number within the collection>* *: <collection identifier (Geology is G)>*
Assigned number	*(not used by PEPN)*
Previous number	*(not used by PEPN)*
Number of items	3 *The number of specimens in, for example, a tube, slide or box to which this record number refers.*
Identification	
Simple name	mollusc *Example: fossil & mollusc* *[Or, if found in a living environment: animal & mollusc or if uncertain whether fossil: mollusc]*
Other name	bivalve *Less general than the previous field, with any relevant common name* *e.g. bivalve or bivalve & cockle*
Full name	Angulus fabulus (GMELIN) *Scientific name (italic font not available in MODES); authority's name, capitalised to avoid confusion with subspecies or variety names)*
System	Linnaean
Authority3	G Spaink, Netherlands Geological Survey, Haarlem *The person responsible for the full name identification. The '3' indicates that this field and the next two are subordinate to the preceding one, in this case Full name.*
Note3	THE SPECIMENS : two right valves and a left valve, nice specimens. Characteristic oblique striations on the right valve. Shells are opaque with concentric bands of brown/reddish brown alternating with white. *brief descriptive notes, condition of items*
Note3	DIAGNOSTICS : for Angulus fabulus, donacinus and pygmaeus (see Tebble, N, 1966, p. 139, 144 -145). Tellinacea with wholly external ligament, approximately oval in outline, the hinge has lateral and cardinal teeth, the valves have concentric lines. In Angulus fabulus, the right

valve also has diagonal striations running from top right to lower left, the umbones are median, shell outline kite shaped, the posterior end is pointed, strongly curved to the right. A. donacinus has the umbones well inside the posterior half of the shell. The right anterior lateral tooth is very long, almost joined to the anterior cardinal. There is a short anterior lateral in the left valve. The posterior end is blunter than A. fabulous. A. pygmaeus has the umbones just behind the midline, the anterior lateral in the right valve does not extend back to the anterior cardinal, there is no anterior lateral in the left valve, the posterior is stumpy and smoothly rounded.

Reference to an authoritative publication, with any personal observations

Status	*Used only if this is a Type, Figured or Noted specimen*
Classified name	Mollusca & Bivalvia & Eulamellibranchia & Heterodonta & Tellinacea & Tellinidae *Hierarchical scientific name - Phylum & Class & Sub-class & Order & Superfamily & Family*
Documentation3	Classification as in Thiele, J. Handbuch der Systematischen Weichtierkunde. 1931. Berlin. Reprint Ascher, Amsterdam 1963. *Source of the classification being used* *In all cases in this collection Thiele's* Handbuch der Systematischen Weichtierkunde was used.
System	Linnaean *The nomenclatural system being used, i.e. Linnean*
Classified name	geology & fossils & molluscs & bivalves *Hierarchical vernacular classification used by Curator*
System	NMS *(Norfolk Museums System)*
Brief description	Mollusc, Angulus fabulus (GMELIN) (bivalve); from borehole from the Holocene deposits North Sea bed, Noordzee borehole 71GD22, collected by Netherlands Geological Survey *a 'calculated field', automatically formed from chosen segments of other fields (and some editing) to give an overview of the object/s.*

Description

Form	shell *('Shell' will not do for all molluscs, e.g. for Chitons, 'plate')*

Description

Part:dimen:reading	largest : height : 13 mm
Part:dimen:reading	largest : length : 22 mm
Part:dimen:reading	smallest : height : 10 mm
Part:dimen:reading	smallest : length : 16 mm
	Fields may be added to take account of the diversity of objects in this record

Field collection

Method	borehole
	e.g. hand collected, borehole, dredged
Person	collector: Netherlands Geological Survey : G Spaink
Date	*(here unknown) format is e.g. 5.1965 (May 1965)*
Place	Netherlands
	If full information is available this might have several part fields. Normally more information is available, for example: South side & North Point & Dunbar & East Lothian & Scotland.
Site name	Noordzee borehole 71GD22
Locality type	borehole
Coordinates	52°25' N, 04°14' E
Note3	sea depth 27.4 m
Stratigraphy	depth : 1.00 - 1.60 m
Stratigraphy	age : Holocene
Stratigraphy	rock: :
	Many of the items in the PEPN collection will contain the vernacular description 'Crag' which means 'shelly sand.'

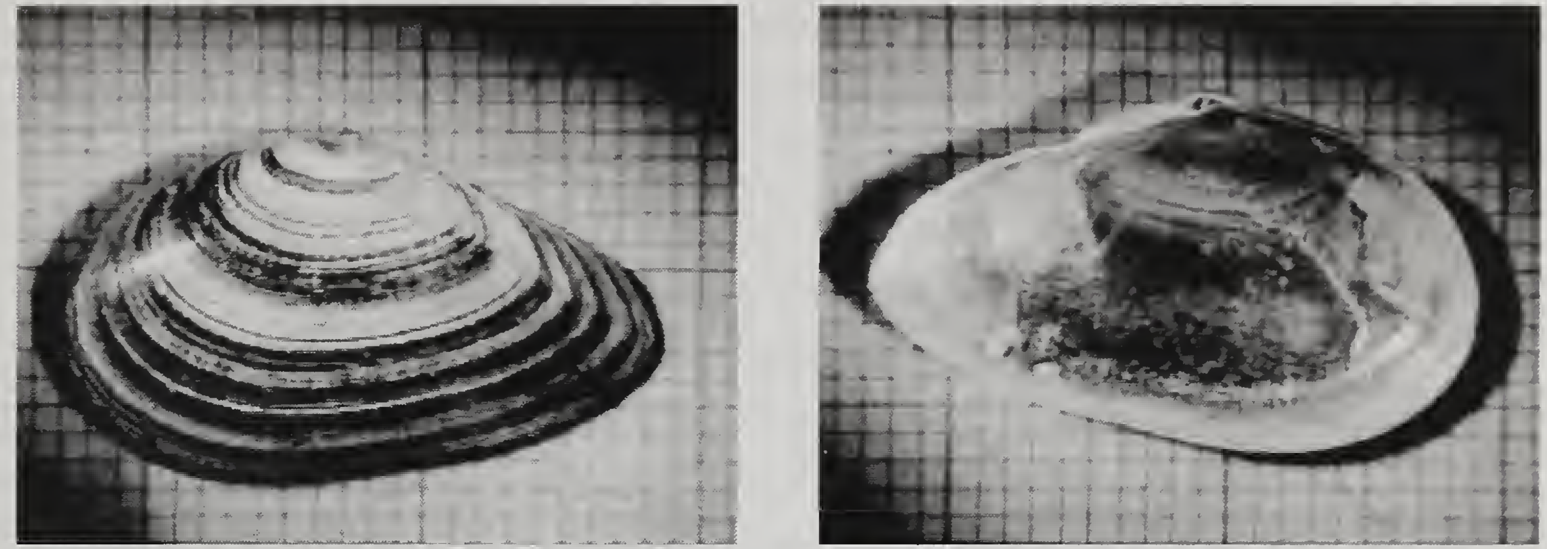
Acquisition	*(by the Museum)*
Method	gift
Person	from : Norton, Peter E.P., Dr
Address	Street Farm House, Shipdham, Norfolk, IP25 7PA
	(As at time of donation, and updatable. This information does not appear on records visible to the public)
Date	4.9.2005
Date	
Note	comparative material determined and donated by G. Spaink
Named collection	P.E.P. Norton Collection

Photography

Summary descript	digital images interior and exterior, all 3 valves
Reference number	geology\1719a.jpg
Reference number	geology\1719b.jpg
Reference number	geology\1719c.jpg
Reference number	geology\1719d.jpg
Reference number	geology\1719e.jpg

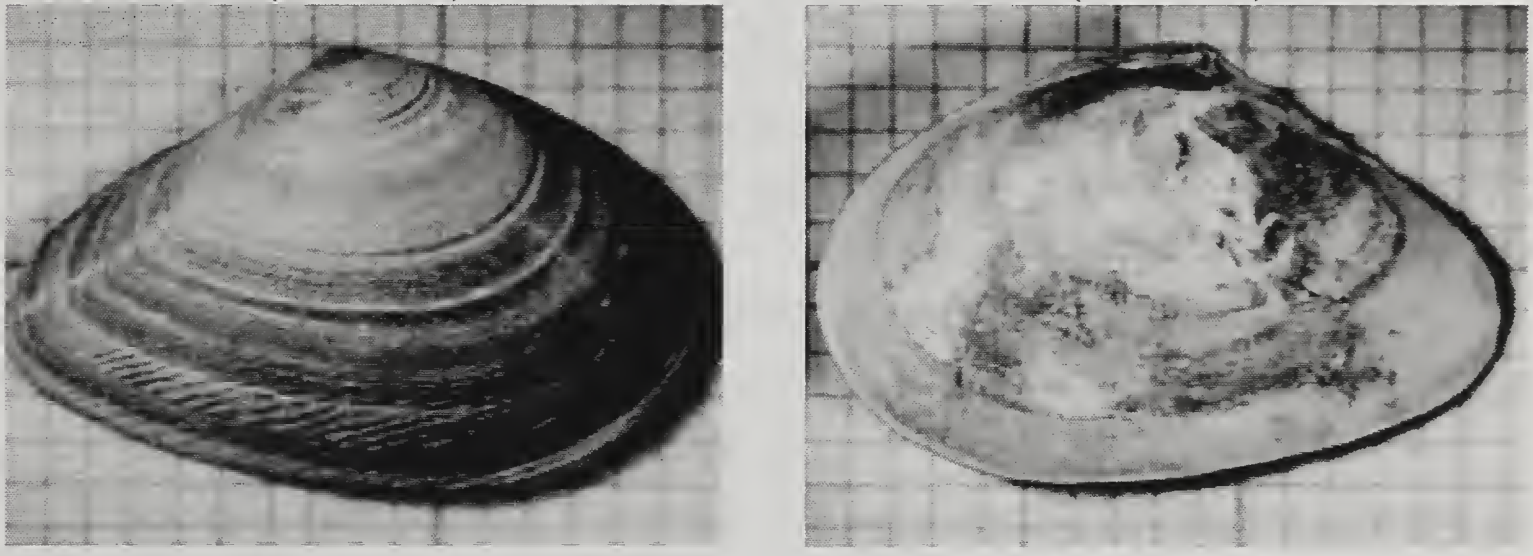
Reference number	geology\1719f.jpg *Reference number (pathname of digital image)* *It is possible to display images other than those of the current record, to which a cross–reference is desired.*
Note3	Scale - a graph paper background is visible in the photos, the small squares are one millimetre *This is not true for every photo. In such cases refer to the Description fields above*
Permanent location	Superstore 1 & Office & Slidemaster metal cabinet & Section 5 & Drawer 36 & Tellinacea : 20.2.2008 *Location of the object (whether in storage, on display or on loan) and the date on which it was placed there. This field will be updated if the location is changed*
Note	stored in glass tube *(this would mean a 25 mm diameter tube; also commonly used were 'large' 50 mm or 'small' 10 mm glass tubes, cardboard cavity slides or boxes depending on specimen type)*
Recorder	PEPN : 20.2.2008 *(Date record made, or most recent modification of the record)*
Conservation	*(This section was hardly ever required)*
Method	
Corporate body	
Date	
Treatment priority	
Documentation group	
Reference	Tebble, N, : 1966, : British Bivalve Seashells, : London, Brit Mus (Nat Hist) *References to monographs and diagnostic works, publications about the specimens or the site, etc*
Documentation	PEPN ringbinder Mollusca 15, Tellinacea : page 2185 *Refers to any associated documentation such as the collector's catalogue or letter of donation.*

Angulus fabulus (GMELIN)



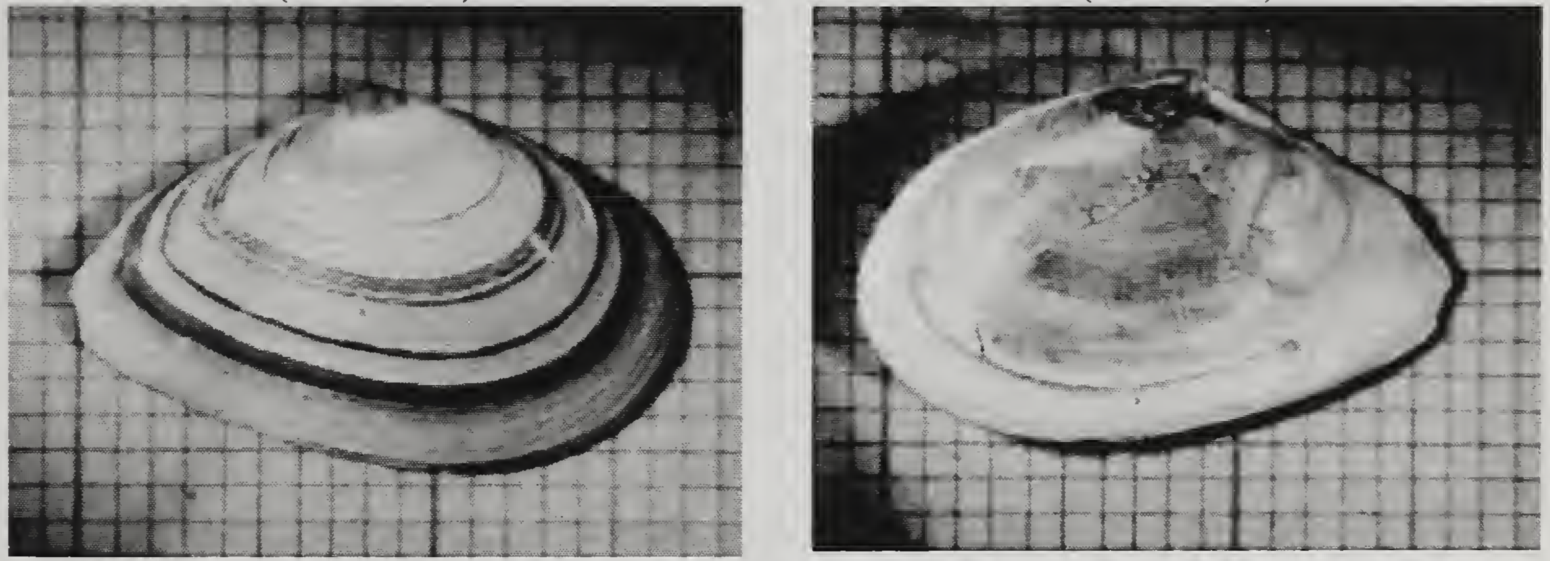
Specimen 1 exterior
(CM01719b)

Specimen 1 interior
(CM01719a)



Specimen 2 exterior
(CM01719d)

Specimen 2 interior
(CM01719c)



Specimen 3 exterior
(CM01719f)

Specimen 3 interior
(CM01719e)

Fig. 2. Images for MODES record NWHCM : 2006.172.1719 : G. Graph paper background small squares are 1 mm.

APPENDIX II

COLLECTORS AND DONORS: SOME BIOGRAPHICAL NOTES

Including a brief list of the Mollusc material from the Crag (and related deposits) at Gressenhall attributable to each

This section has been compiled from accession and donation records in NCM, printed obituaries and from *The Oxford Dictionary of National Biography*. It is hoped that it will eventually be expanded into a rather more detailed account of those who were influential in the development of geology in Norfolk.

Alexander, Capt Henry: Army engineer officer in the Royal Staff Corps (disbanded in about 1837). Philip Cambridge notes him as a collector in the Norwich area, whose material is included in the Reeve Collection. Paper by him *Proc. Geol Soc.* **10** p. 334 (1854).

- G273 Drawers 4, 6, 7, 8 Bulchamp
- G274 drawer 6, 7 Bramerton
- G274 drawer 8; Thorpe (Norwich).

Bell, Alfred: 1835–1925. Contemporary and friend of F.W. Harmer. He was personally known to Murchison, Sedgwick, Lyell, Owen and many others. He became a collector, with his brother Robert, a year or two older than himself, at the age of about eleven years (*Nature, **117**, 130–130, 23 January 1926).*

Obituary: *op. cit*; *Quart. Jour. Geol. Soc. London* **1926**; *Essex Naturalist 1926,* **26**, *213–219;* List of publications in Markham, R, *Geosuffolk Notes* **8**. Often noted as 'collector' but no collection is named as his own.

- G273 drawer 12, Orton, in H. Norton Collection; Gedgrave
- G273 drawer 15 Red Crag (no loc.)
- G274 drawer 3, Sizewell
- G770 Red Crag (or Harmer)
- G778 Waldringfield, Butley, Woodbridge, Sutton, Chillesford
- G779 Butley, Shottisham
- G780 Sutton in H Norton Collection, Waldringfield or Orton.

Buxton, Reverend F. Arthur: At the time of his death (date uncertain) he lived at Earney, Ware, Hertfordshire. His collection was presented to NCM by his son, Alfred F. Buxton, in 1887.

- G274 drawer 15, 'Chillesford, Buxton Collection'
- G275 drawer 2 'Norwich crag Misc incl. Chillesford, Buxton collection'
- G762 Red Crag. no loc, 'Buxton Collection'
- G764 Red Crag. no loc, 'Buxton Collection'
- (G770 Red Crag. no loc, 'coll. By Buxton'
- G775 'Buxton Collection Red Crag'
- G777 Red Crag. no loc, 'Buxton Collection'
- G787 'Buxton Collection Red Crag'.

Cambridge, Philip C.: 1918–1993. Served with the R.A.F and collected in numerous places abroad. His principal interest was the Crag Mollusca. On leaving the R.A.F he was for 15 years Chief Technician and Research Assistant in the School of Environmental Sciences at UEA, Norwich. Obituary in *Journal of Conchology* (1994) **35,** 83–86. He reviewed and identified shells in many of the Norwich Castle Museum collections. His own collection was bequeathed to the Sedgwick Museum, Cambridge. The undernoted specimens, unless otherwise stated, are 'identified by P. Cambridge'.

- G273 drawer 9, Bramerton, 'H. Pulley'; drawer 13, Coralline Crag; drawer 15, Coralline Crag.
- G274 drawer 1, Belaugh, Coltishall, Brundall (?), Wroxham Old Hall; drawer 2, Belaugh, Coltishall; drawer 5, no loc. ; drawer 7, Wroxham Old Hall, Belaugh, Coltishall; drawer 8 Bramerton Common (Alexander Collection), Westerschelde (Netherlands Eemian); drawer 11, Bramerton; drawer 14, Aldeby ('Coll. Rev J Crompton')
- G275 drawer 12, Aldeby, Orford
- G278 drawer 1, Easton Bavents & Bramerton shells compared; drawer 9, 'Chillesford, S.V. Wood'
- G764 Aldeby '(Crowfoot & Dowson)'; Blake's Pit Bramerton 'ex P. Cambridge collection'
- G765 Bridlington Crag; Icenian, Postwick; Aldeby '(Crowfoot & Dowson Collection)' ; 'Postwick W. B Wigham'
- G777 Red Crag, no loc.; Coralline Crag, no loc.

Charlesworth, Edward: 1813–1893. A medical student turned geologist, Honorary Curator of Ipswich Museum from 1835–1840, Curator of the Yorkshire Museum 1844–1858, collector of fossils in the field and by purchase. His innovations included the division of the Suffolk Crag into Coralline and Red Crag (1835), and the use (and manufacture) of round glass-topped boxes for museum specimens. Biographical details in Geol. Mag. 1893, p. 526–528 and Markham, R 1976 , Notes on Edward Charlesworth 1813–1893 *Ipswich Geological Group Bulletin* **18**. pp 14–16. Henry Norton – see below - used to buy specimens from him.

- G273 drawer 12 Coralline Crag
- G778 Chillesford.

Crompton, Reverend Joseph: Founding President of the Norfolk and Norwich Naturalists' Society in 1869. Lived in Brackendale. Presented material to NCM between 1840 and 1871. Date of death uncertain, possibly 1879.

- G274 drawer 14, Aldeby.

Crowfoot, William Miller, M.B., F.R.C.S. (Eng.), L.S.A., J.P.: 1838–1918. A physician and surgeon practicing in Beccles, Suffolk (collaborator with Dowson, also Davey). Part of his collection is in a cabinet in the Castle Museum (23 drawers of Crag specimens). The following items are at Gressenhall:

- G1009 specimens from Selsey
- G273 drawer 11 Coralline Crag
- G275 drawer 1 Aldeby
- G278 drawer 1 Bramerton or Easton Bavents
- G306 drawer 6/7 Coralline Crag Sudbourne (some Davey material)
- G764 & G765 Aldeby, Crowfoot and Dowson
- Cabinet kept on shelving Row D (no accession number visible) collection from the 1870s, 18 drawers holding trays with up to 48 wooden pill boxes; Bramerton, Aldeby, Sizewell, Beccles, Yarn Hill, Easton Bavents, Dunwich, Bulchamp, Wangford, Kessingland, Thorpe (Aldringham?), Sudbourne, Barnwell, Corton, Hopton, Hampshire and Paris Basin Tertiaries, Mosbach. Has been looked through by R. Markham.

Davey: (see Crowfoot). No biographical details found. No donation records in NCM.

- G306 Aldeby.

Dowson E.T.: (see Crowfoot). No biographical details found. No donation records in NCM.

- G764 & G765 Aldeby.

Ellis, Edward Augustine: 1909–1986. Keeper of Natural History in Norwich Castle Museum from 1929 to 1963. Obituary: *Eastern Daily Press* 23 July 1986.

- G273 Drawers 1, 2 Easton Bavents (1949).

Fitch, Robert: 1802–1895. Chemist and druggist in Norwich. A contemporary of Darwin, and a collector of Cretaceous barnacles which Darwin used to borrow from him. Though principally interested in archaeological material, he collected widely in the Crag deposits. The Fitch Room in NCM contains a selection from his collection. Obituary *in Geol. Mag.* 1895, p. 527.

- G273 drawer 1, 11, 12, Coralline Crag
- G274 drawer 8, Bramerton.
- G274 drawer 13 (no Loc.) ‘Fitch Room’
- G277 drawer 1 & 2, Freshwater Bed
- G278 drawer 3, Bramerton, Postwick (possibly Fitch)
- G279 drawer 1, no loc. (shark teeth),
- G 279Drawer 3 no loc. (possibly Fitch)
- G280 drawer 8 (Red Crag) ‘some Fitch Collection’
- G771 Red Crag, Oakley

Gregory, J: No biographical details found. No donation records in NCM.

- G278 drawer 1 Bramerton?

Gunn, Reverend John: 1801–1890. Clergyman, Rector of Irstead and Barton Troy in Norfolk from 1841–1869, resigned from dissatisfaction with Anglican dogmatics. Fossil collector in the Crag and Cromer Forest Bed deposits. His material has been incorporated into the Reeve Collection. Obituary: *Proc. Geol. Soc. London* **47**, pp 57–58 (1891). *‘Memorials of John Gunn’* (H. B. Woodward & E.T. Newton, *eds.* , 1891, ref. below) provides information about his formative influence in Norfolk Geology and many amusing anecdotes.

- G273 drawer 6, Mundesley, Wroxham.
- G273 drawer 7, Bramerton (Blake's), Horstead Mill
- G273 drawer 8, 'Recent'
- G273 drawer 9, Butley ('J Gunn and J Reeve')
- G274 drawer 9, Bawdsey (sheet with list)
- G764 Chillesford ('J Gunn and J Reeve')

Harmer, Frederic William: 1835–1923. Clothing manufacturer in Norwich, collaborator with S.V. Wood Snr and Jnr and Alfred Bell. (*qq.v*). With S.V. Wood Jnr (*q.v.*) he carried out the first geological survey of East Anglia. Mayor of Norwich 1887–1888; during his mayoralty he suspended his geological work. Author of *The Pliocene Mollusca of Great Britain* 1914–1925. Obituary in *Trans. Norfolk and Norwich Naturalists' Society (1923)* **11,** 477–483. His collection of Mollusca was donated to the Sedgwick Museum, Cambridge. A few specimens are in the Type and Figured cabinet in Norwich Castle Museum, others are in the British Museum (Natural History) and the following are at Gressenhall:

- G277 drawer 6, March gravels.
- G278 drawer 3 (Harmer comments on shelly grey gravel specimen)
- G306 drawer 11 Coralline Crag, Gedgrave, Ramsholt 'rec'd Harmer'. Notes by R. Markham.
- G764 Reeve Collection specimen (?Bramerton) *Natica borealis* with ?Harmer notes 'to be figured' – not in "Pliocene Mollusca" (R. Markham note)
- G770 Red Crag shells with Harmer or Bell handwriting.

Hawes, S: No biographical details found. Collector of Red Crag. May have lived in Coltishall. Donated material to NCM in 1839: apparently his material was kept distinct in the Castle Museum, the type of boxes used is the same as in the H. Norton and J. Reeve Collections (see Reeve, below).

- G778 Red Crag, include Bawdsey, Waldringfield. ('Hawes Collection')

Lee, J.E.: No biographical details found.

  - G764 Bridlington *Saxicava rugosa* det. by Lee.

Norton, Henry: 1812–1892. One-time solicitor, traveler, man of letters in Norfolk and fossil collector. He bought some of his material from Charlesworth (see above). The type of specimen boxes used is the same as in the S. Hawes and J. Reeve Collections (see Reeve, below).No mention in NCM donors register. Biography: *Geol. Mag. (Dec.* **3***) vol.* **9** .p. 192 (1892) and *Eastern Daily Press*, February 24th, 1892.

  - G274 drawer 5 (no location, unidentified.)
  - G778, Red Crag. Orton, Sutton, Woodbridge
  - G779, Red Crag. Shottisham ('A. Bell 1873'), Waldringfield
  - G780, Red Crag. Waldringfield
  - G1110 (S V Wood Collection) Freshwater Bed, Runton
  - Empty Cabinet from the H Norton Collection, Gressenhall shelving Row C.

Pulley, Henry: No biographical details found. Philip Cambridge notes him as a collector in the Norwich area, whose material is included in the Reeve Collection. NCM records donations from him made 1860–1879.

  - G273 drawer 6, Postwick, 'by Woodward .' 2 items
  - G273 drawer 9, Bramerton (label by P. Cambridge)
  - G274 drawer 8, Bramerton (displaced label by P. Cambridge).

Reeve, James: 1833–1920. Assistant (1847), then Curator (1852–1910) and Honorary Curator (1910–1920) in Norwich Museum; first in St Andrew's Street and then in Norwich Castle. There was a distinct collection of his which is still mostly together in the 'Bisley Cabinets', G273–G 279, at Gressenhall. Reeve collaborated with Alexander, Gunn, Hawes, Norton and Pulley. Apparently Reeve standardised the specimen boxes used in all these collections. Labels of Reeve's own collection are printed or typewritten. Reeve added to the Type and Figured collection, now in the NCM. The NCM library inherited from him a quantity of Norwich School of Painting works and a correspondence file between him and J. H. Gurney, collector of raptorial birds, dated 1856–1890. Obituary by F. W. Harmer. *Proc. Geol Soc. Lond.* **77**, p 71–72.

- G273 drawer 4 Bramerton (Blake's)
- G273 drawer 5 Bramerton (Blake's)
- G273 drawer 6 Bramerton (Blake's) and Bramerton Common; Bulchamp 'Capt Alexander'; Mundesley (John Gunn); Postwick 'Henry Pulley'; Wroxham (John Gunn)
- G273 drawer 7 Bramerton (Blake's) [presumed to connote 'Bramerton Lane', 'Bramerton *Scrobicularia* bed']; Bramerton Common; Bulchamp, 'Capt Alexander'; Horstead; Methwold (includes "*Pecten* presented by Mr J Reeve Nov 1854").
- G273 drawer 8 Bramerton Common; Bramerton, Blake's; Bulchamp ('Capt Alexander'); Bramerton (Blake's); Butley (J Gunn & J Reeve)
- G274 drawer 2 Belaugh; Brundall; Postwick
- G274 drawer 6 Belaugh; "Bramerton" [Common]; "Bramerton Lane" [Blake's]; Brundall; Happisburgh (Forest Bed); Horstead; Thorpe (Norwich); Postwick; 'Runton'; "Thorpe (Aldeburgh)"[Aldringham]; Weybourne; Wroxham
- G274 drawer 9 Bawdsey (& John Gunn, *q.v.*)
- G274 drawer 12, "J Reeve bequest' a pearl and a calcified operculum.
- G275 drawer 1 Norwich Crag misc
- G275 drawer 3, Belaugh; Thorpe (Norwich)
- G275 drawer 9, Broome
- G275 drawer 13, Bramerton, Yarn Hill
- G275 drawer 15, Bramerton, Yarn Hill
- G277 drawer 13, West Runton
- G279 drawer 8, Bramerton, Coltishall (Reeve, Rogers)
- G764 Bramerton (delicate juvenile *Modiolus*, Reeve comment 'derived' [!] (and many other items one of which is the Harmer 'to be figured' specimen, *q.v.* Harmer); estimates of frequency; specimens sent to S.V. Wood for determination Oct 1878.
- G764 Bridlington specimens determined by J E Lee (q.v.)
- G769 Bramerton.

Rogers: No biographical details found. No donation records in NCM.

- G279 drawer 8, Bramerton, Coltishall ('Reeve, Rogers').

Rose, Caleb Burrell: 1790–1872. Surgeon and geologist, who practiced in Swaffham for 43 years. Collector, principally occupied on the Middle and Lower Chalk and the 'Brickearth' of West Norfolk. Obituary: *Geol. Mag. (issue* **94**) vol. **9** p 191.

- G273 drawer 13 Coralline Crag echinoid
- G277 drawer 3 'Rose Collection.' ? Nar Brickearth.
- G280 drawer 1, Nar Valley 'Rose Collection.'

Savin, Alfred Collison: ?1861–1948. A Cromer shopkeeper whose premises in Church Street were "… filled with elephant teeth, amber and silver ware …" (*Eastern Daily Press*, see below). His main interests were said to be amber and mammalian fossils. He collected Forest Bed fossils from the 1880s until the 1940s; most of his specimens were purchased by the Natural History Museum, London. See Savin, A.C. 1950, *Cromer in the county of Norfolk. A modern history by the late Alfred Collison Savin*, revised 1st edition, Rounce & Wortley, Holt, 144 pp. Obituary: *Eastern Daily Press* 9 February 1948, 5.

- G280 drawer 7 Weybourne Crag, shells det. by R. Markham.

Steward, George: No biographical details found. NCM records donations 1939–1960.

- G273 drawer 1 Easton Bavents, Fish remains.

Wood, Searles V. Snr & Jnr: S. V. Wood Snr (1798–1880), naval officer in the East India Company, retired 1826, and his son (1830–1884), a solicitor (retired 1864) were authors of *'The Crag Mollusca'*, one of the earliest publications of the Palaeontographical Society. Their collection, including material from many Tertiary localities in Britain and abroad, is one of the few which has been kept discrete during the moves from NCM to Gressenhall. Any work undertaken on it in the future will require conservation of the specimen labels, often written in pencil and very dusty. The original S V Wood Cabinet had 81 drawers (now empty, stored in Superstore 2 shelf E). Their contents have been transferred to 71 plastic trays now in Superstore 1 Mezzanine. Obituary: *Proc. Geol Soc. Lond.,* **41**, pp 40–41 (1885).

- Outline list of the S V. Wood collection in Table 1 (below).

Woodward, Samuel: 1790–1838. Apprenticed as a weaver, in trade until 1812, clerk in Norwich Union 1840–1820, in Gurney's Bank, Norwich, 1820–1838. He collected on the Norfolk coast (bones), published books and articles, and corresponded with many leading geologists of his day (one was Caleb Rose, see above). Obituary: *Geol. Mag.* **NS 8**, (1) pp 1–8 (with signed portrait).

Woodward, Dr. Henry: 1832–1921. Youngest son of Samuel Woodward. Officer in Gurney's bank 1851–1858; Assistant in the Geological Dept of the British Museum 1858–1880, Keeper from 1880–1901, oversaw the move to South Kensington; founded (1864) and edited (until 1918) the Geological Magazine. His main field of interest was fossil Crustacea and other Arthropoda.

The only references to the Woodwards were as identifiers of specimens.

- G274 drawer 13 no locality *Serripes groenlandicus* (S Woodward)
- G273 drawer 6 Postwick '*Natica groenlandica/ Natica pusilla* by Dr Woodward'
- G273 drawer 6 Bulchamp, Reeve Collection, Capt Alexander '*N. pusilla and Paludina media / P. lenta* of [H?] Woodward'

Appendix II **Table 1**: The S. V. Wood Collection

Tray	Original Drawer	Deposits / Sites
G1085	1	Paris Basin Tertiaries
G1086	2	
G1087	3	
G1088	4	
G1089	5	
G1090	6	
G1091	8	
G1092	8	
G1093	9	
G1094	10	Belgian Tertiaries
G1094	11	
G1095	11	
G1095	12	
G1096	12 – 13	
G1097	14	
G1098	15	
G1098	15	Bordeaux Tertiaries
G1099	15	
G1100	16	
G1101	17	
G1102	18	
G1103	19	
G1103	20	
G1104	20	
G1104	21	
G1105	21 – 23	
G1106	23	
G1107	24	Paris Basin Tertiaries Sicilian Pliocene, and a letter
G1108	25	Continental Tertiaries 'and American shells' (no bags marked as such)
G1109	26	Red Crag, Felixstowe
G1110	27	Selsea etc (Glacial).
G1110	27	Freshwater Bed Runton, H. Norton.
G1110	27	Grays, Clacton, Stutton.
G1110	27	Brentford
G1110	28	Hampshire Basin Tertiaries
G1111	29	
G1112	30	
G1113	31	
G1114	32	British Lower Tertiaries
G1115	33	
G1116	34	Hampshire Basin Tertiaries
G1117	35	British Lower Tertiaries
G1118	36	Hampshire Basin Tertiaries
G1119	37	
G1120	38	British Lower Tertiaries
G1122	40	Hampshire Basin Tertiaries
G1123	41	British Lower Tertiaries
G1124	41	
G1124	42	
G1125	43	Coralline Crag
G1125	45	
G1126	44	
G1127	45	
G1127	46	
G1129	47	
G1129	48	Coralline Crag, Sutton etc
G1130	49	Coralline Crag
G1131	48	Coralline Crag, Sutton etc
G1131	50	
G1132	48	
G1132	50	
G1132	51	
G1133	51	
G1133	52	
G1134	55	Coralline Crag, Sutton, Ramsholt, Tattingstone & Gedgrave

Tray	Original Drawer	Deposits/ sites
G1135	54	Coralline Crag (misc)
G1136	53	
G1136	54	
G1137	56	Coralline Crag, Sutton & Orford
G1139	59	Red Crag, Sutton
G1140	59	Red Crag Misc – Sutton
G1141	60	Red Crag, Felixstowe etc & misc
G1142	61	Red Crag, Felixstowe
G1143	62	Red Crag Felixstowe & misc
G1143	63	Red Crag misc
G1144	63	Red Crag, Butley, Sudbourne & misc
G1144	64	Red Crag misc
G1145	65	Red Crag
G1145	66	Red Crag & misc
G1146	65	Red Crag misc
G1146	67	Icenian misc
G1147	67	Icenian Crag, Ditchingham, Coltishall, Horstead, Runton, Burgh *etc*
G1147	68	Upper FW Bed
G1148	69	Icenian Crag, Belaugh
	70	
G1149	71	Corton Beds
	72	
G1150	71	Corton Beds misc
G1150	74	Pleistocene marine including Clacton, Stutton etc
G1151	73	Pleistocene marine including March, Clacton, Stutton etc
G1151	74	Pleistocene FW
G1152	75	Grays, Copford, Clacton & Stutton
G1152	77	Recent shells
G1153	76	
G1153	77	
G1154	76	
G1154	79	
G1155	78	
G1156	80	

BACK ISSUES OF THE BULLETIN OF THE GEOLOGICAL SOCIETY OF NORFOLK AND 50th JUBILEE VOLUME

The Geological Society of Norfolk (GSN) has back issues of the Bulletin available for purchase as outlined below. The Bulletin may not be easily available at some institutions - except through Inter-Library Loan – so individuals might consider a recommendation for purchase by institution libraries.

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If you would like to place an order please discuss your requirements with Julian Andrews at UEA, preferably on the following e-mail address: j.andrews@uea.ac.uk

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ASPECTS OF ICHNOLOGY OF CHALK AND SANDSTONE CLASTS FROM THE BEACH AT OVERSTRAND, NORTH NORFOLK

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ABSTRACT

Clasts of Chalk from the beach between Overstrand and Cromer, north Norfolk, include a limited diversity of modern borings. Caulostrepsis *isp. cf.* C. taeniola *Clarke appears to avoid boring in belemnite guards, unlike* Entobia *isp. This may be, in part, due to the differing life habits of the producing organisms; annelids (producing* Caulostrepsis*) can choose their substrate with greater care than laterally propagating colonial organisms like clionoid sponges (producing* Entobia*). The bivalve* Zirfaea crispata *(Linné) is recognised as a modern producer of* Gastrochaenolites *isp. cf.* G. ornatus *(Kelly & Bromley). A partial* Gastrochaenolites *isp. of unusually large size (29-33 mm in diameter) demonstrates that large modern borings are present in Norfolk Chalk, but are rarely preserved in clasts.*

An erratic of finely-laminated sandstone preserves at least five escape shafts, Monocraterion *isp. These were possibly produced by bivalves in the Pennsylvanian (Upper Carboniferous). This is a rare example of an erratic preserving an ancient trace.*

INTRODUCTION

The beaches of north Norfolk between Overstrand and Cromer, and beyond, are a source of innumerable clasts for the obsessive geological beachcomber. The great majority of these are flints, derived from the Upper Chalk, and although they display myriad variations of form and colour, they are of little interest to the palaeontologist except in the rare instances that they retain well preserved fossils (e.g., Donovan & Lewis, 2011, fig. 4). But among the flints are rarer clasts of locally-derived Upper Cretaceous Chalk and erratics released from Pleistocene fluvio-glacial deposits. Both of these can provide interesting data for field

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Bull. geol. Soc. Norfolk (for 2010), **60**, 37- 45.

geologists. Other ‘rocky’ fragments are man-made, mainly concrete and brick.

Herein, I describe and discuss the ichnology of some clasts recently collected from this area during fieldwork to supplement earlier ichnological and palaeontological research. Clasts from Chalk are mainly of interest because they provide hard substrates to modern borers. Although the borings of clionoid sponges (*Entobia* isp.) and annelids (*Caulostrepsis* isp.) are common, the rarer borings of bivalves are particularly prominent because of their size (Donovan, 2011). Erratics have not excited ichnological interest until now, but a cobble from the Upper Palaeozoic(?) contains common and intriguing burrows.

MATERIAL AND METHODS

The cobbles described herein are deposited in the collection of the NCB (formerly Nationaal Natuurhistorisch Museum) - Naturalis, Leiden (RGM). They were collected on the beach between Overstrand and Cromer, north Norfolk (Fig. 1), during late July 2010. Examination of specimens was by hand lens and binocular microscope. Specimens were photographed by the author using a Canon PowerShot G11 digital camera.

Descriptive terminology of borings follows Häntzschel (1975) and others. My philosophy of open nomenclature follows Bengtson (1988).

CHALK CLASTS

Recent borings are a common feature of the Chalk clasts of the north Norfolk coast (Donovan & Lewis, 2010, 2011; Donovan, 2011). The most common taxa are *Entobia* ispp. and *Caulostrepsis* isp. cf. *C. taeniola* Clarke, 1908; sections through the latter bear a superficial resemblance to *Rogerella* isp. More rarely, clasts are perforated by one or more *Gastrochaenolites* isp.; *Gastrochaenolites ornatus* Kelly & Bromley, 1984, is the only nominal ichnospecies confidently identified. The notes below refer to new information gleaned about the morphology and producers of these borings.

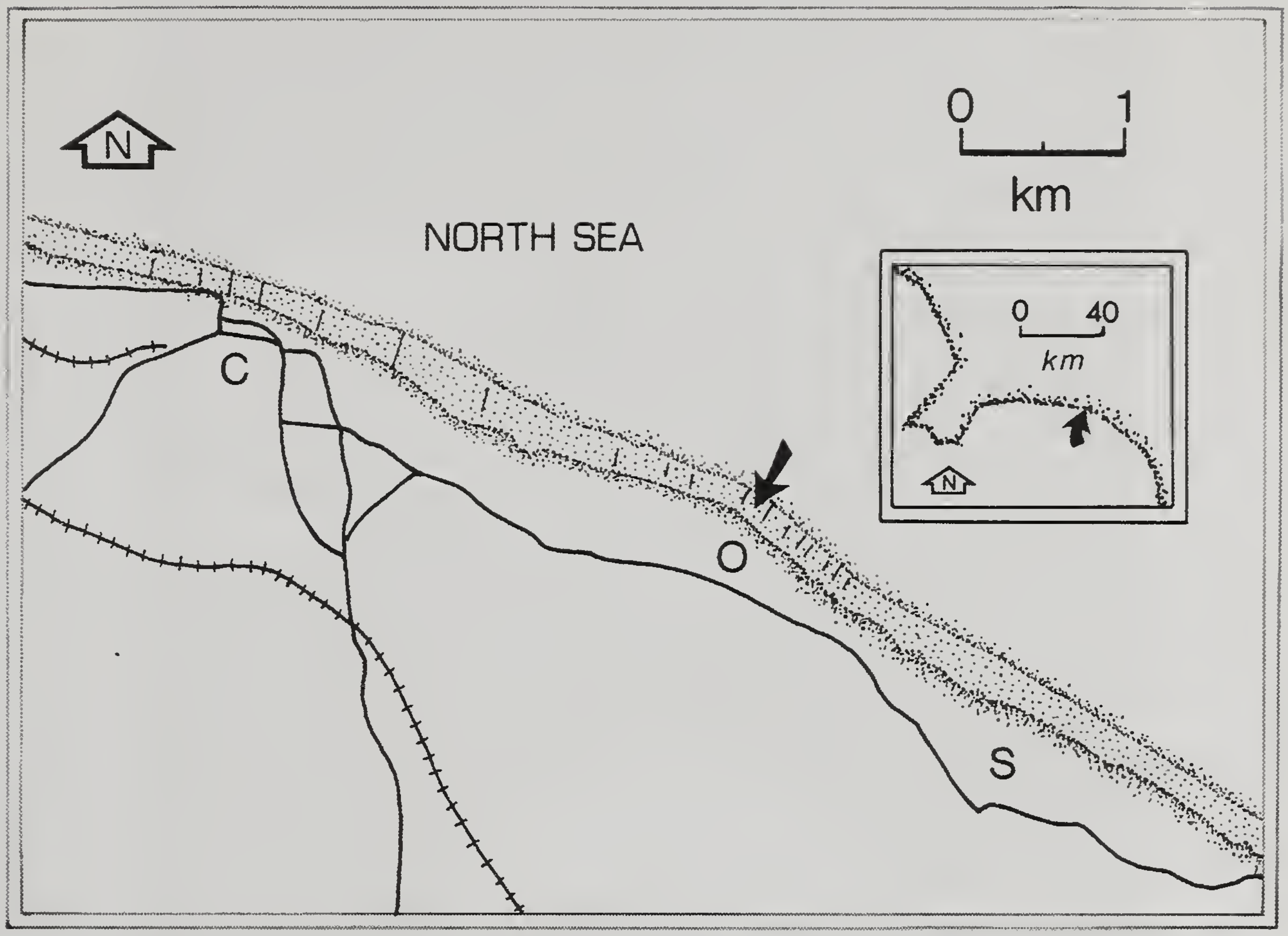

Fig. 1. Outline map of the north coast of Norfolk between Cromer (C), Overstrand (O) and Sidestrand (S), after Donovan (2010, fig. 1). The dark arrow indicates the author's point of access to the beach. The stippled area is between the low water mark and cliff top; it includes both the beach (groynes are indicated) and slope of the cliffs. Principal roads are shown as solid lines; railways are shown as trellised lines. The inset map, with a stippled coastline, shows part of the east coast of England, with Lincolnshire (left), the Wash (towards bottom left) and Norfolk (centre and right). The area of the main map is arrowed.

Belemnites and borers

Donovan & Lewis (2010) demonstrated that modern *Entobia* isp. infest Chalk belemnite guards that had been bored by similar sponges during the Late Cretaceous. It is therefore illuminating to figure a Chalk clast in which common borers have avoided infesting a belemnite (Fig. 2A; RGM 617 922). This clast has a moderate infestation of modern *Caulostrepsis* isp. cf. *C. taeniola*, but only in the chalk matrix, not in the belemnite guard.

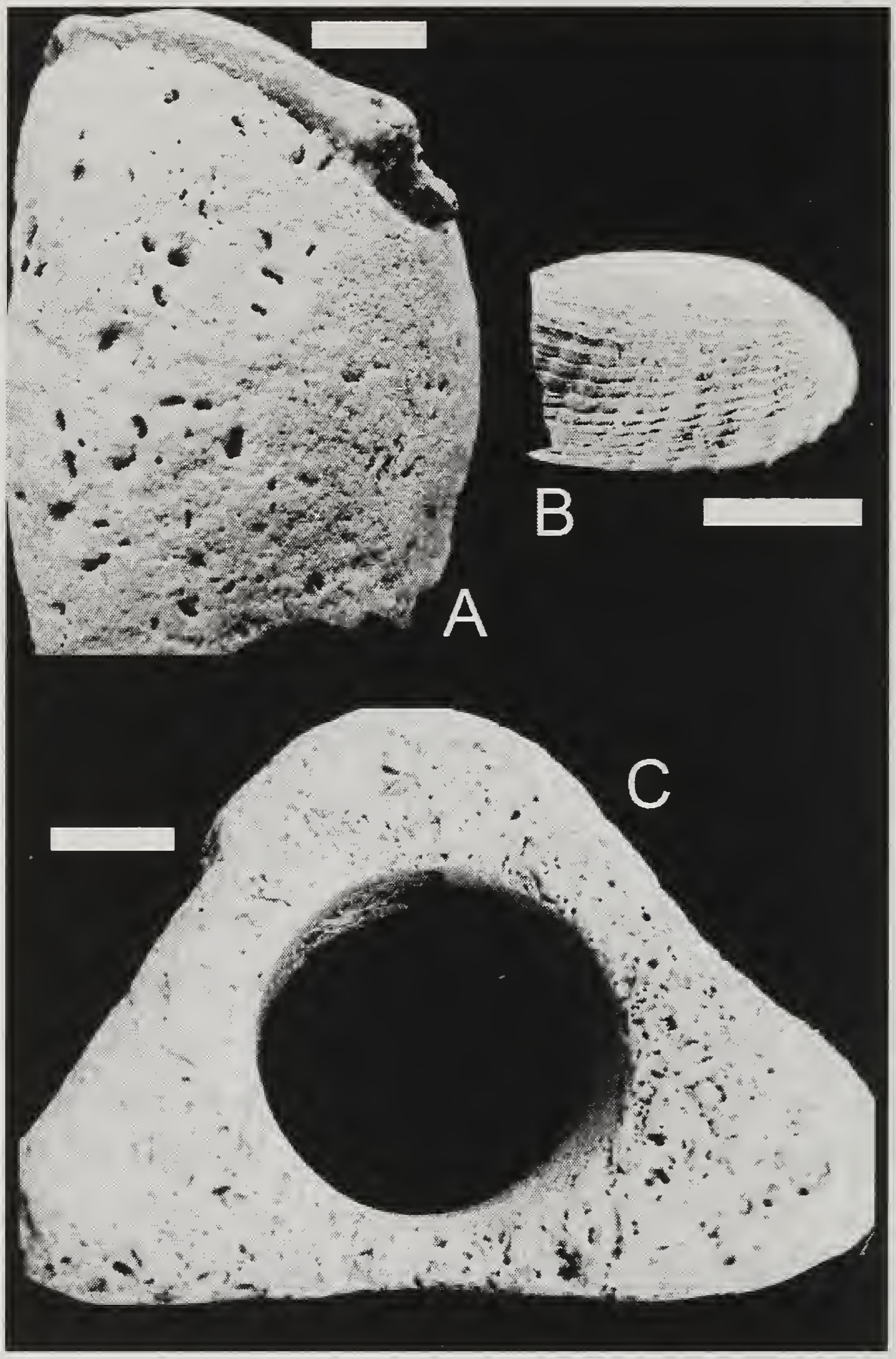

Fig. 2. Borings and borers in Chalk substrates from the north Norfolk coast. (A) RGM 617 922, Chalk clast preserving a belemnite guard (top) which is surrounded by individual annelid borings, *Caulostrepsis* isp. cf. *C. taeniola* Clarke. (B) RGM 617 923, *Zirfaea crispata* (Linné), incomplete right valve, removed from *Gastrochaenolites* sp. cf. *G. ornatus* Kelly & Bromley. (C) RGM 617 924, *Gastrochaenolites* isp., specimen of unusually large diameter, more proximal end (narrower, but better preserved). Scale bars represent 10 mm.

These contrasting patterns can be explained by the different ethologies of the producing organisms. *Caulostrepsis* is the spoor of individual annelid worms, each producing one boring, which have chosen the more porous Chalk as a substrate rather than the denser belemnite guard. In contrast, *Entobia* is the trace of colonial clionoid sponges. That is, the multiple chambers of *Entobia* are linked in life and extending the colony involves infesting adjacent areas of substrate. An adjacent belemnite guard is thus not avoidable by the colony, but neither is it a deterrent to growth.

A producing organism for north Norfolk Gastrochaenolites

Gastrochaenolites is commonly produced by boring bivalves (Kelly & Bromley, 1984); similar borings are excavated by Recent coralliophilid gastropods and some sipunculan worms (Bromley, 2004, p. 462). The fine specimen of *G. ornatus* Kelly & Bromley, 1984, described by Donovan (2011), had been broken open by persons unknown presumably to remove the shell of the producer. It is therefore pleasing to report a *Gastrochaenolites* from the same area which retained part of the shell of its producer. The bivalve is *Zirfaea crispata* (Linné, 1758), the oval piddock (Fig. 2B; RGM 617 923) that was removed from a boring of *Gastrochaenolites* sp. cf. *G. ornatus*, the bioglyph (sculpture) at the base of the chamber being indistinctly preserved. The bivalve is preserved as the anterior of the right valve only, but it is quite distinct. *Zirfaea crispata* is a well known borer of limestone substrates (Tebble, 1976, p. 182).

Large Gastrochaenolites

Gastrochaenolites isp. is invariably incomplete. Not uncommonly it is just a fragment, a section across a shaft, transverse or longitudinal, or the dish-like basal chamber. These rarely present much morphological detail and it is only an unusually complete specimen, such as that documented by Donovan (2011), that encourages description. Again, the Donovan (2011) specimen is relatively large, an unusual characteristic, most specimens having a diameter of only 10-15 mm. It is therefore noteworthy to illustrate a very incomplete specimen that is part of an unusually big boring (Fig. 2C; RGM 617 924). The narrower end has a diameter fractionally under 29 mm; the specimen is about 50 mm in length and broader at the other (more basal) end, about 33 mm in diameter, but less well preserved. That there are large boring bivalves living in Chalk substrates offshore in this area is thus demonstrated. The producer was a large bivalve; again, *Zirfaea crispata* is a likely culprit.

SANDSTONE CLAST

Erratics are a diverse, albeit uncommon, feature of north Norfolk's beaches. The diversity is beautifully displayed by the exhibition of Norfolk erratics in the Cromer Museum, spread over two drawers, including: a Jurassic? ammonite, Jurassic limestone, a Jurassic plant stem, an ichthyosaur vertebra, a Mississippian (Lower Carboniferous) colonial coral, jet and jasper; and rhomb porphyry, quartz porphyry, sandstone, larvikite, syenite, granite, agglomerate, conglomerate, gneiss, garnet-mica schist and Hertfordshire puddingstone. As the label of the first drawer states, "An enormous variety of "foreign" erratic material can be found in Norfolk" and even this long list isn't comprehensive (for example, add Mississippian cherts; Donovan, 2010).

The clast described herein (Fig. 3; RGM 617 925) is sandstone and, therefore, not an exceptional erratic lithology (see above), but it is significant for its ichnology. The clast is an oval cobble with a side broken off by a recent fracture. Maximum length is about 117 mm, width about 71 mm (slightly fractured on one side) and thickness about 34 mm (probably closer to 43 mm before breakage). Details of lithology are better observed when wet. The sandstone is medium- to coarse-grained, with thin pale grey laminae (2-3 mm thickness) alternating with thinner (1-2 mm thick) maroon laminae. Some darker grey laminae are also present. Lamination is perpendicular to the width of the clast and angled at about 60° to its length.

The ichnological content of this clast comprises at least five narrow, vertical, unlined burrows that each deflect the adjacent thin laminae downwards. These are included in *Monocraterion* isp. and are interpreted as escape burrows. None is seen in its entirety as the cut is not perpendicular to lamination, whereas the burrows most probably were so. Maximum diameter is about 3 mm and the longest length observed is about 21 mm. Two burrows have an infill of maroon sandstone, the others are grey. Burrows occur throughout most of the thickness of the clast, but the two with the maroon infill appear to be at about the

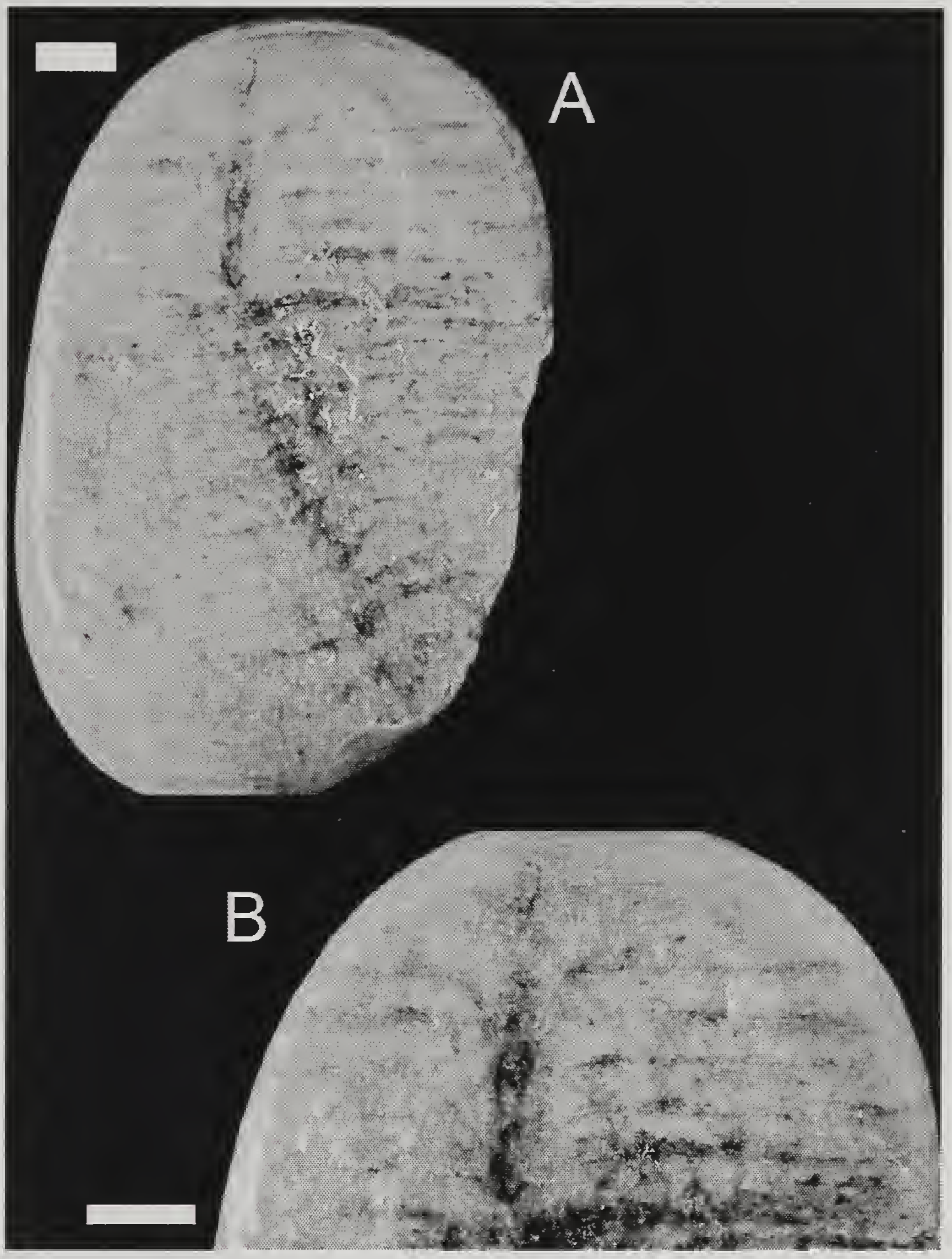

Fig. 3. Sandstone clast, RGM 617 925, an erratic from the beach between Overstrand and Cromer (GPS TG 244 413) preserving *Monocraterion* isp. as escape shafts. Possibly Pennsylvanian (Upper Carboniferous). (A) General view of broken side of clast, showing one prominent escape shaft. (B) Close up of prominent escape shaft in (A). Specimen made wet with water to emphasise sedimentology and ichnology. Scale bars represent 10 mm.

same level. The burrows are, of course, indisputable way up structures.

The origin of this clast is equivocal, but most probably it is Upper Palaeozoic, possibly Pennsylvanian (Upper Carboniferous). I base this interpretation on both the sedimentology and the ichnology, although identification is more difficult than, say, the Mississippian (Lower Carboniferous) chert erratics known from certain Crag and younger deposits (Moorlock *et al.*, 2002). Escape structures are well known from the deltaic and Coal Measure sandstone successions of the Pennsylvanian of northern England (see, for example, Hardy & Broadhurst, 1978, fig. 2; Broadhurst *et al.*, 1980; Eagar *et al.*, 1985, pl. 12, figs C, D), the most probable source area for such a clast. Other origins, while possible (e.g., Permo-Triassic), seem less probable.

ACKNOWLEDGEMENTS

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Copies of the Bulletin (including older back copies) can be obtained from the editor at the address on p.1; it is issued free to members.

The illustration on the front cover is figure 2 (rotated 90°) from the article by Donovan in this issue of the Bulletin. It shows borings and borers in Chalk substrates from the north Norfolk coast. (A) Shows a Chalk clast preserving a belemnite guard (top) which is surrounded by individual annelid borings, *Caulostrepsis* isp. cf. *C. taeniola* Clarke. (B) Shows an incomplete right valve of *Zirfaea crispata* (Linné), removed from *Gastrochaenolites* sp. cf. *G. ornatus* Kelly & Bromley. (C) shows a *Gastrochaenolites* isp., specimen of unusually large diameter, more proximal end (narrower, but better preserved). Scale bars represent 10 mm.

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